CHAPTER 9. SHIPMENTS ANALYSIS

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CHAPTER 9. SHIPMENTS ANALYSIS

9.1 INTRODUCTION

Estimates of product shipments represent a necessary input for calculations of national energy savings (NES) and net present value (NPV). Shipments are also a necessary input for the manufacturer impact analysis (MIA), which the U.S. Department of Energy (DOE) conducts for its notices of proposed rulemaking (NOPRs). This chapter describes DOE's methodology for projecting annual shipments and presents results for each of the sets of products considered in this rulemaking (i.e., water heaters, direct heating equipment, and pool heaters).

DOE used a separate shipments model to estimate shipments for each product. Each shipments model estimates shipments for specific market segments, then aggregates those results to estimate total product shipments. The shipments models, which are Microsoft Excel spreadsheets, are accessible on the Internet (http://www.eere.energy.gov/buildings/appliance_standards/). Appendix 9-A, User Instructions for Shipments and National Energy Savings Spreadsheet Model, describes how to access and use the shipments model and other related spreadsheets. The rest of this chapter explains the shipments models in more detail. Section 9.2 describes the methodology for each product covered in the shipments model; section 9.3 describes the data inputs and model calibration; and section 9.4 discusses how standards could affect shipments.

9.2 METHODOLOGY FOR SHIPMENTS MODELS

DOE developed national stock models for estimating annual shipments of the products considered for this energy conservation standards rulemaking. The shipments models treat market segmentation as a distinct input to the shipments forecast. As represented by the following equation, the two primary market segments used (which are common to all products except direct heating equipment) are new installations and replacements.

$$Ship_p(j) = Rpl_p(j) + NI_p(j)$$

Where:

$Ship_p(j)$ = total shipments of product class p in year j,
$Rpl_p(j)$ = units of product class p retired and replaced in year j, and
$NI_p(j)$ = number of new installations of product class p in year j.

Rather than simply extrapolating a shipments trend based on recent data, the shipments analysis uses driver input variables, such as construction forecasts and product lifetime distributions, to forecast sales in each market segment. For example, DOE's shipments models assume that construction of new housing units drives installations in new housing. In each year, the product shipments for the new construction market segment are equal to the number of new housing units built times the purchase rate, which is determined by the market share of the product under consideration.

DOE's shipments models take an accounting approach, tracking market shares of each product class, the vintage of units in the existing stock, and expected construction trends. The models estimate shipments of replacements using sales in previous years and assumptions about the lifetime of the product, which estimates how long the product is likely to remain in stock. The following equation represents how DOE estimated replacement shipments.

$$Rpl_p(j) = \sum_{age=0}^{ageMax} \sum_{j=N}^{j-1} Ship_j \times prob_{Rtr}(age)$$

Where:

$prob_{Rtr}(age)$ = probability that an appliance of a particular age will be retired, and

N = start year for when the model begins its stock accounting (start year, which is based on historical shipments data, is specific to each product).

Stock accounting uses product shipments and a retirement function as inputs to develop an estimate of the age distribution of in-service product stocks for all years. The age distribution of in-service product stocks is a key input for calculating both the NES and NPV, because operating costs for any year depend on the age distribution of the stock. Operating costs are dependent on product age distribution under a standards-case scenario that produces increasing energy efficiency over time. This means that older, less energy-efficient units may have higher operating costs, while younger, more energy-efficient units have lower operating costs.

9.3 DATA INPUTS AND MODEL STRUCTURE

DOE's shipments models develop a total stock of direct heating equipment by integrating historical shipments. Over time, some units are retired and, therefore, removed from stock, triggering the shipment of a new unit. Because of the relationship between retirements and total stock, there is a strong correlation between past and future shipments.

DOE estimated new construction shipments using new housing forecasts and estimates of product market shares in new housing. New housing includes newly constructed single- and multi-family units, referred to as "new housing completions," along with mobile home placements. To forecast new housing units, DOE used actual data through 2009,[1] and adopted the projections of housing starts and placements of manufactured homes from the Early Release (December 2009) of the DOE Energy Information Administration's (EIA's) *Annual Energy Outlook 2010* (*AEO2010*) for 2010–2035.[2] Figure 9.3.1 presents historical new housing completions and forecasted housing starts and placements of manufactured homes based on *AEO2010* for 1990–2035. For 2035–2045, DOE kept completions constant at the 2035 level.

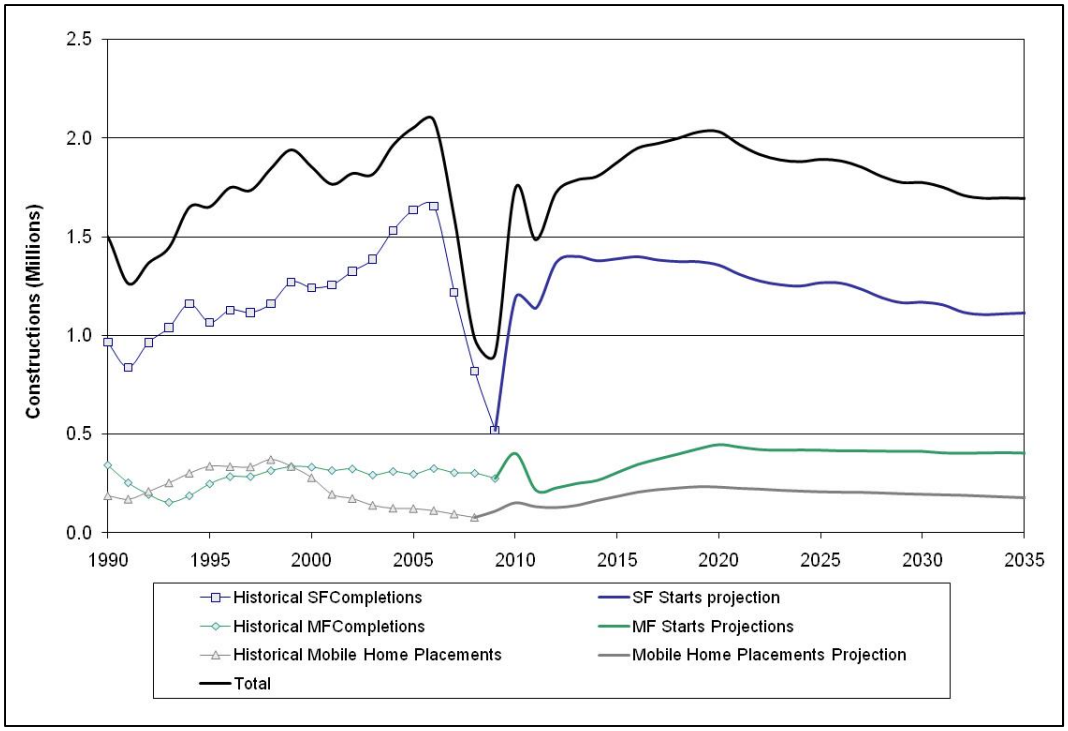

Figure 9.3.1 Historical Housing Completions and Forecasted Housing Starts

DOE estimated replacement shipments using product retirement functions developed from product lifetimes. For all products, DOE based the retirement function on a triangular probability distribution for the product lifetime. The shipments models assume that no units are retired below a minimum product lifetime, and that all units are retired before exceeding a maximum product lifetime. The models use the following equation to determine the probability of retirement at a certain age for all products.

$$R_{y,class} = \sum_{v=L\min}^{L\max} FR_{class}(v) \times S(y-v)_{class}$$

Where:

$R_{y,class}$ = replacements,
v = product vintage,
$S(y\text{-}v)$ = shipments in the year y-v, and
$FR_{class}(v)$ = fraction of each cohort that will be replaced at each vintage.

The summation runs from the minimum to the maximum lifetime. The sum of the replacement fraction is equal to 1.

The following sections describe the data inputs for each product.

9.3.1 Water Heaters

9.3.1.1 Historical Shipments

DOE used historical shipments data (domestic shipments and imports) provided by the Air-Conditioning, Heating, and Refrigerating Institute (AHRI)[3] to populate its shipments model for water heaters. For gas-fired instantaneous water heaters, DOE also used data for 2008, along with an estimate of 2009 shipments, provided by A.O. Smith in its comments on the NOPR. Figure 9.3.2 shows the past trend for each product class.

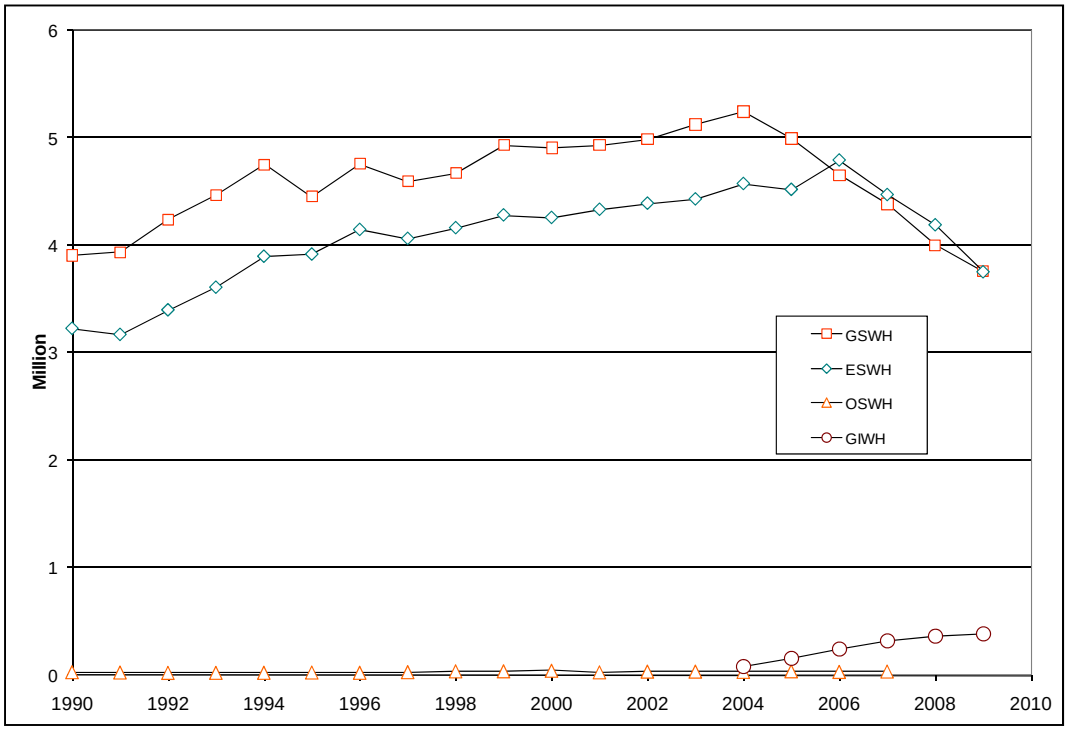

Figure 9.3.2 Historical Shipments by Water Heater Product Class

9.3.1.2 Markets and Model Structure

New Construction. DOE used information on the choice of water heater products in recently-built housing to estimate shipments to the new construction market. Table 9.3.1 shows the historical market share data found in new construction between 2000 and 2007, by fuel (gas, electricity, or oil) as given by the *American Housing Survey*. The future market shares of water heaters using a particular fuel were assumed to follow the average pattern in new homes for 2000–2007 throughout the forecast period. Section 9.4.1 discusses the potential effects of energy conservation standards on choice of water heater product in the new construction market.

Table 9.3.1 Historical Water Heater Market Shares by Fuel Type in New Construction

Year Built	Gas, LPG	Electricity	Fuel oil
2000	43.8%	49.5%	0.2%
2001	48.7%	44.1%	0.3%
2002	48.4%	45.5%	0.1%
2003	51.1%	42.5%	0.2%
2004	52.9%	40.9%	0.2%
2005	47.5%	45.2%	0.2%
2006	46.0%	47.6%	0.1%
2007	46.8%	45.4%	0.2%
Average	48.2%	45.1%	0.0%

Replacements. DOE determined shipments for the replacement water heater market using an accounting method that tracks the stock of units. Depending on vintage, a certain percentage of each type of unit will fail and be replaced. To determine when a unit fails, DOE used a survival function based on a distribution of product lifetimes having an average value for gas-fired storage water heaters, electric storage water heaters and oil water heaters of 13 years, with minimum and maximum values of 6 and 20 years. For a more complete discussion of water heater lifetimes, refer to chapter 8. Figure 9.3.3 shows the retirement functions that DOE used to estimate replacement shipments for water heaters.

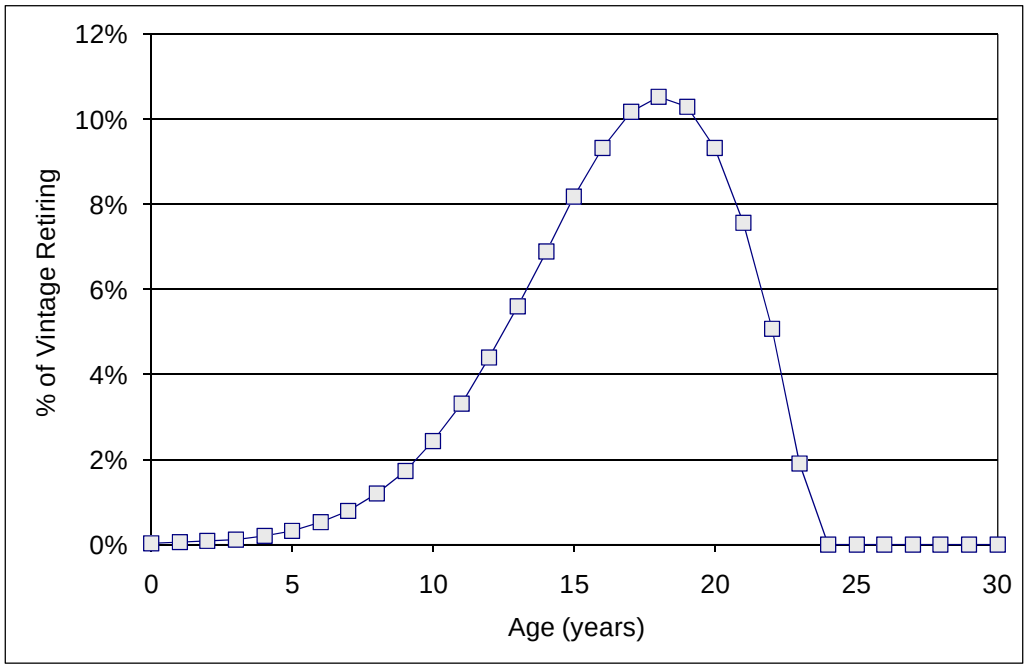

Figure 9.3.3 Water Heaters: Retirement Functions

The shipments model for water heaters assumes that when a unit using a particular fuel is retired, it generally is replaced with a unit that uses the same fuel. (Section 9.5.1 describes situations in which buyers may switch to a product that uses a different fuel.) Within the category of gas-fired water heaters, DOE disaggregated the percentages of gas-fired storage

water heaters and gas-fired instantaneous water heaters based on projections of total shipments of gas-fired instantaneous water heaters.

Gas-Fired Instantaneous Water Heaters**.** Gas-fired instantaneous water heaters are in the early stage of what is likely a considerable growth in market share. The growth will derive from two sources: installation in new construction, and replacement of storage water heaters with instantaneous water heaters. In addition, replacements of installed instantaneous water heaters with another instantaneous water heater are expected to increase during the next 20 years.

Because there is considerable uncertainty about the future of instantaneous water heaters, DOE modeled three scenarios for their market penetration. The scenarios are based on experience with instantaneous water heaters in Australia, where the proportion of instantaneous water heaters in total gas-fired water heater shipments has grown considerably in the past decade. Residential water heating services and technology in Australia are roughly comparable to those in the United States. Storage water heaters have somewhat lower volume capacities in Australia, but end-use hot water demand also may be lower.

For the evolution of the Australian water heater market, DOE relied on a recent study conducted as part of a proposal to introduce a minimum energy performance standard for gas-fired water heaters.[4] In discussing the changing mix of gas-fired storage water heaters and gas-fired instantaneous water heaters, the report states:

> Our baseline puts gas-fired storage water heater and instantaneous water heater penetration, in 2005, at 27 percent and 11 percent respectively. It seems certain that instantaneous water heater penetration will increase further and that gas-fired storage water heater penetration will fall, but there is uncertainty about the timing and extent of the changes. Our baseline scenario is that, by 2015, gas-fired storage water heater and instantaneous water heaters will each have 50 percent of the installed stock of gas-fired water heater. This means that both converge on a total market penetration of 20 percent in 2015 and then grow in line with projected penetration for gas-fired water heaters, reaching 21 percent in 2020. (p. 10)

Combining the above penetration scenario with the projections of sales (shipments) results in a 45:55 split between gas-fired storage water heaters and gas-fired instantaneous water heaters for 2010–2020.

A major factor behind the popularity of gas-fired instantaneous water heaters in Australia is that their prices are roughly comparable to prices of gas-fired storage water heaters (excluding installation costs). In the United States, gas-fired instantaneous water heaters currently cost about twice as much as typical 40-gallon gas-fired storage water heaters. Although the price differential in the United States will probably decrease, the United States market will probably not duplicate the Australian market. Nonetheless, DOE believes that the market evolution in Australia provides an approximate model for scenarios for the United States.

DOE's scenario of high future market penetration of gas-fired instantaneous water heaters in the United States assumes that maximum penetration in the United States will be the same as projected for Australia (55%). The medium and low scenarios assume that the maximum penetration rate for the United States will be respectively half and a quarter of the high scenario (27.5% and 13.75%). Based on historical data on U.S. gas-fired instantaneous water heater shipments from 2004 to 2009, a S-shape function has been parameterized to forecast future penetration of gas-fired instantaneous water heaters. S-shape functions are commonly used to describe diffusion of new technology. DOE used a Gompertz function defined as:

$$MS_{IGWH}(y) = MS_{Max} \times \exp(\gamma \times \exp(\beta \times (y - y_0)))$$

Where: $MS_{IGWH}(y)$ is the Market Share of gas-fired instantaneous water heaters in the year *y;* MS_{Max} is the maximum Market Share of gas-fired instantaneous water heaters; γ and β are parameters of the Gompertz function that are determined by a fit on historical data; and y_0 is the first year for which data is available (2004).

A linear equivalence of the equation above is:

$$\ln(\ln(MS_{Max} / MS_{IGWH}(y))) = \ln(-\gamma) + \beta \times (y - y_0)$$

A linear regression is performed on the linearized Gompertz function for each of the three scenarios. Table 9.3.2 summarizes the results. Figure 9.3.4 shows the resulting trends in market penetration.

Table 9.3.2 Parameters Used in the Determination of Penetration of Gas-fired Instantaneous Water Heaters

Scenario	MS_{Max}	γ	β	R^2
Medium	27.50%	-2.67	-0.20	97.4%
Low	13.75%	-2.09	-0.35	99.5%
High	55.00%	-3.34	-0.14	96.2%

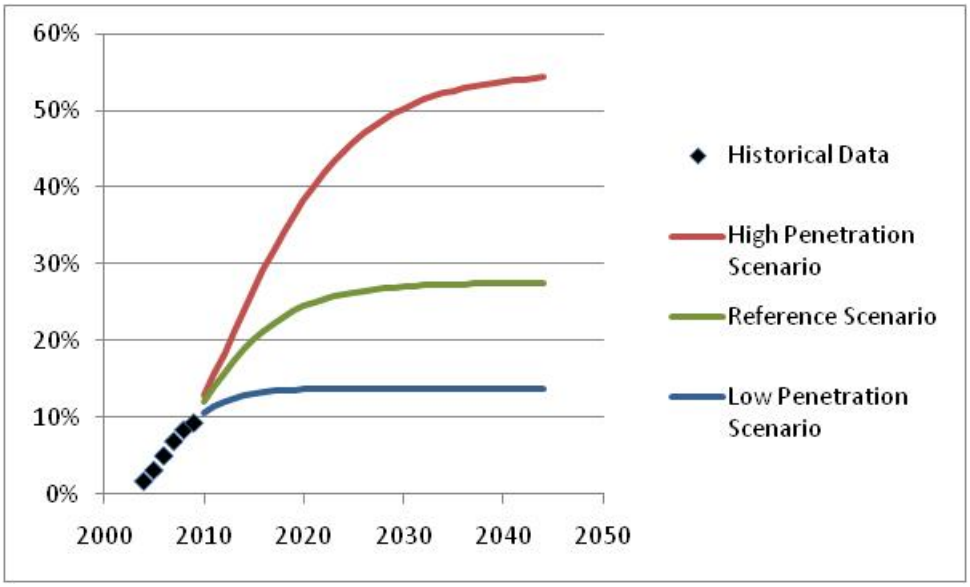

Figure 9.3.4 Scenarios of Market Penetration of Gas Instantaneous Water Heaters in the United States Market for Gas Water Heaters

The projected shipments of gas-fired instantaneous water heaters are the sum of shipments that represent switching from gas-fired storage water heaters, installations in new homes, and replacements-in-kind (that is, when a retired instantaneous water heater is replaced with the same type of product). In the case of switching from a gas-fired storage water heaters to a gas-fired instantaneous water heater, a product that has a longer lifetime (gas-fired instantaneous water heater) replaces one having a shorter lifetime (gas-fired storage water heaters). Over time, therefore, total shipments of gas-fired water heaters are less than they would have been in a market comprised only of gas-fired storage water heaters.

9.3.2 Direct Heating Equipment

9.3.2.1 Historical Shipments

DOE used four primary data sources to estimate historical shipments of direct heating equipment, beginning with data for 1990–2006 that AHRI provided in March 2008.[3] In May 2008, AHRI provided DOE with a second set of data that included 2002–2006 shipments for gas wall gravity DHE and gas wall fan DHE for the representative product classes only.[5] DOE also used shipments information from the 1993 TSD.[6] Finally, in comments on the NOPR, AHRI stated that shipments of traditional DHE decreased by 22% between 1989 and 1999, and DOE used this information to estimate total sales in 1989.

AHRI's March 2008 data for wall furnace shipments is not disaggregated by gas wall gravity and gas wall fan DHE, but is instead disaggregated by vented wall furnaces and direct-vent wall furnaces. To estimate the proportions of gas wall gravity and gas wall fan DHE from total vented and direct-vent wall furnaces, DOE used information from the 1993 TSD. This

information was used to establish the equipment percentages for 1990–2001: 86.5 percent for gas wall gravity DHE, and 13.5 percent for gas wall fan DHE. For 2002–2005, DOE developed total shipments of gas wall fan DHE based on the May 2008 data for the representative product class (more than 42 thousand British thermal units per hour) and the fraction of gas wall fan DHE shipments by product class from the 1993 TSD. To determine shipments of gas wall gravity DHE, DOE subtracted the estimated shipments of gas wall fan DHE from total wall furnace shipments.

The Hearth, Patio and Barbecue Association (HPBA) has data available online (http://www.hpba.org/statistics/hpba-us-hearth-statistics) about shipments for all fireplaces, freestanding stoves, inserts, fireboxes, and gas logs between 1998 and 2008. Based on HPBA data for 2003 and 2004 that includes fireplaces, fireplace inserts and stoves only, DOE estimated that 42 percent of these shipments are gas hearth DHE. This fraction was used for the other years as well.

For gas floor DHE, AHRI provided shipment data for 1990–1999 on March 3, 2008,[3] and data for 2000–2007 on March 11, 2008.[7]

Figures 9.3.5 and 9.3.6 show the historical shipments developed for each product class of direct heating equipment.

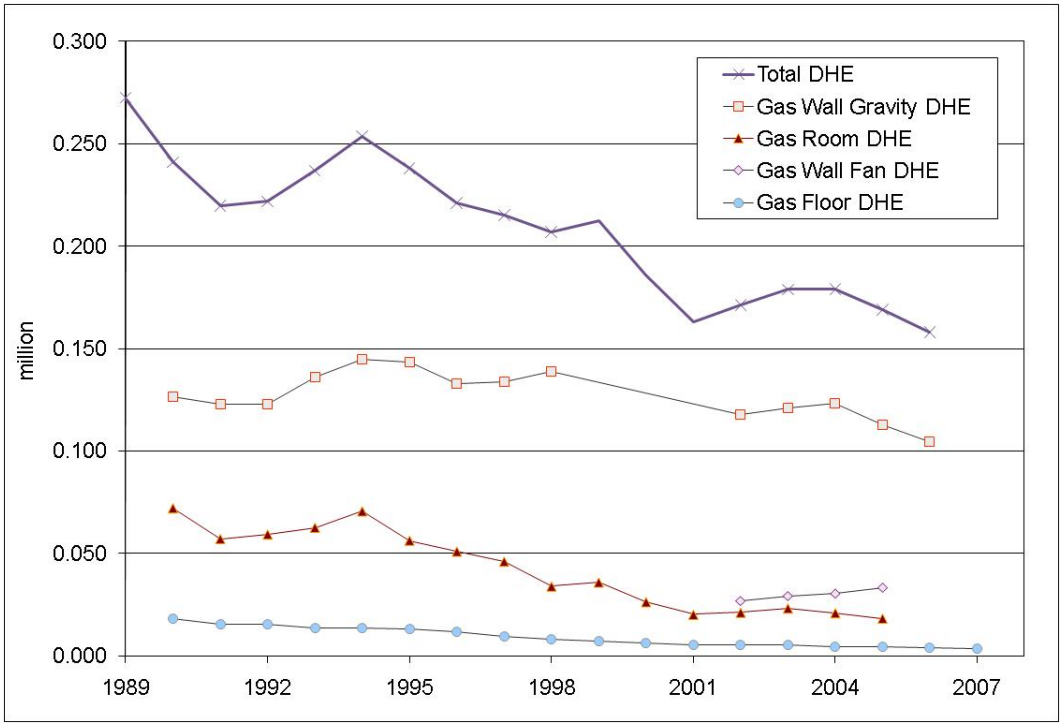

Figure 9.3.5 Direct Heating Equipment: Historical Shipments

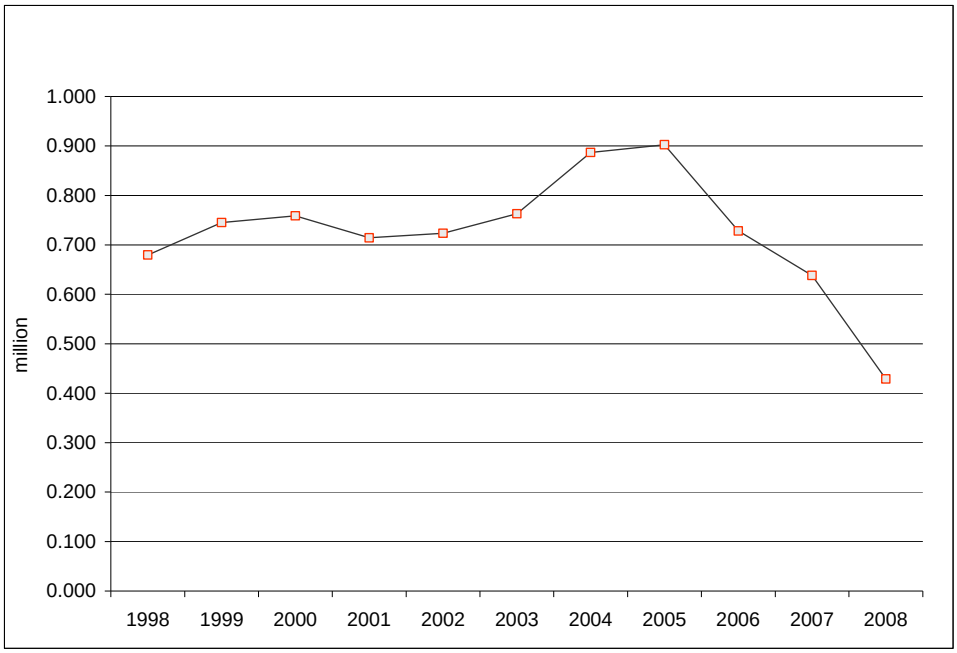

Figure 9.3.6 Gas Hearth DHE : Historical Shipments

9.3.2.2 Modeling Approach

Data were unavailable to develop separate forecasts of direct heating equipment shipments for replacement and new home installations, so the forecast through 2043 was based on the historical total shipments developed for each product class and comments from manufacturers.

Based on comments from AHRI and its assessment of the market, DOE projected that the sum of total traditional DHE will decrease by 30% over the forecast period. DOE decreased the shipments of gas room DHE by 30% over the forecast period from the 2005 level. Forecasted gas floor DHE shipments follow the downward trend for 2000–2007. For gas wall fan DHE, DOE performed a linear regression on historical data to determine future trends of shipments. DOE derived gas wall gravity DHE shipments as the remainder from total traditional DHE and the sum of the other shipments described above.

For hearth product shipments, DOE found that historical shipments and new housing completions between 1998 and 2008 had a coefficient of correlation of 0.96. This correlation reflects both the installation of hearth products in new homes and the fact that housing construction and purchase of hearth products in existing homes are sensitive to general economic activity. On average, hearth product shipments in this period were equal to 56% of the number of new completions. DOE forecasted the shipments of hearth products using the above fraction and the *AEO2010* new housing forecast cited earlier.

9.3.3 Gas-Fired Pool Heaters

For gas-fired pool heaters, DOE started with historical shipments data through 1990, taken from the 1993 Technical Support Document (TSD) for gas-fired pool heaters.[6] For years after 1990, shipments were estimated using a model of market segments. As with other heating products, market segments for pool heaters comprise new construction and replacements. In addition, DOE included a segment for existing households that install a pool heater for the first time (first-time owners).

9.3.3.1 Markets and Model Structure

New Construction. To forecast pool heater shipments for new construction for any given year, DOE multiplied the forecasted housing starts by the estimated saturation of gas-fired pool heaters in new housing. Based on a report from PKData,[8] DOE estimated the saturation of gas-fired pool heaters in recently built single- and multi-family housing to be 1.3 percent. This saturation was used for the entire forecast period.

Replacements. Depending on vintage, a certain percentage of pool heaters will fail and be replaced. To determine when a unit fails, DOE used a survival function based on a distribution of product lifetimes having an average value of 10 years, with minimum and maximum values of 3 years and 20 years, respectively. For a more complete discussion of pool heater lifetimes, refer to chapter 8. Figure 9.3.5 shows the retirement function that DOE used to estimate replacement shipments.

DOE determined that a significant fraction of owners of pool heaters do not replace the product when it fails.[12] Reasons for non-replacement include high cost of fuel, change of the household needs, and difficulties in operating the pool heater. For its forecast, DOE estimated that 30 percent of units that are due for replacement (based on the survival function) are not replaced.

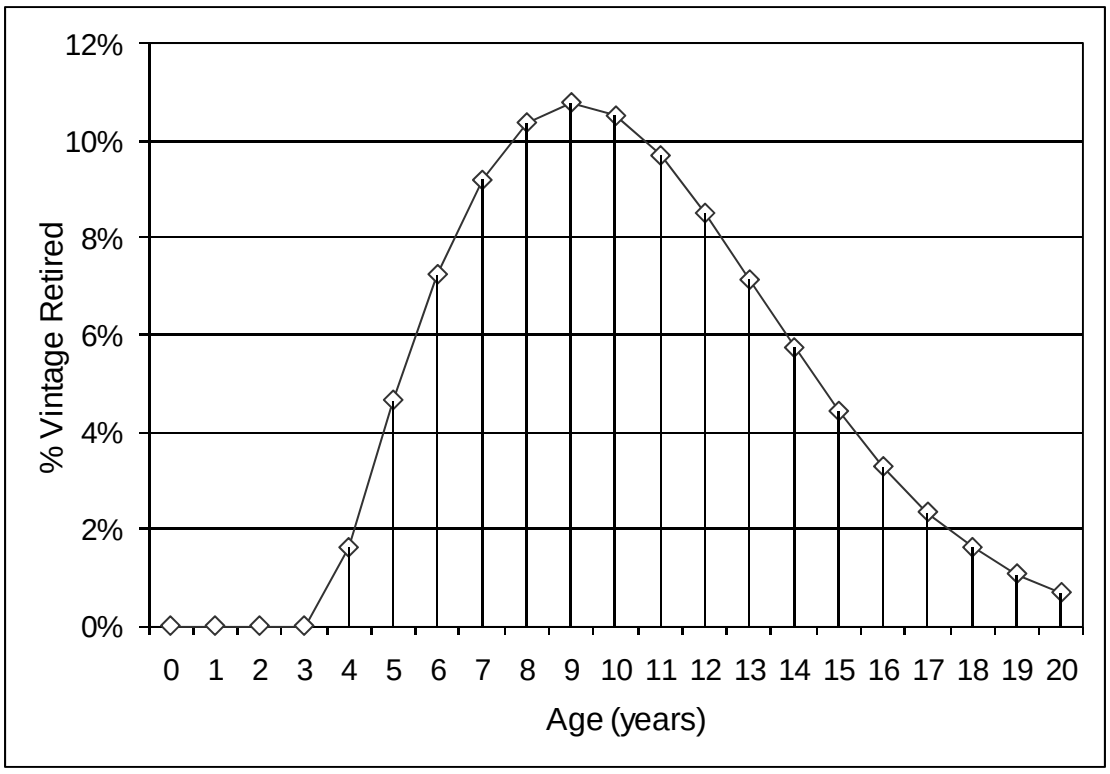

Figure 9.3.7 Gas-Fired Pool Heaters: Retirement Function

First-Time Owners. DOE introduced into the shipment model for pool heaters a market segment representing purchases by existing households that previously had not owned a pool heater. These first-time owners (FTOs) refer to existing households that install a pool heater in a new pool. Historical FTO shipments were based on estimates of annual construction of new swimming pools and the fraction of new swimming pools with gas pool heaters, provided by PKData. Historical FTO shipments are determined as the remainder of total shipments, once replacements and new construction installations are determined.

In order to forecast FTO shipments, DOE calculated the ratio of FTO and new housing installations to housing starts between 2000 and 2009. Between 2010 and 2013, DOE used the 2009 ratio, which is substantially lower than the 2000-2008 values, to forecast the total FTO and new housing installations, assuming the market will need a few years to recover from the recession. After 2013, DOE used the average ratio between 2000 and 2009. To estimate only FTO shipments, DOE subtracted the estimated shipments to new homes (derived as described above) from the shipments of all new (non-replacement) pool heaters.

9.4 FORECASTED SHIPMENTS

9.4.1 Water Heaters

Figures 9.4.1 through 9.4.4 show the modeled and actual historical shipments of water heaters in each product class. Differences between actual and modeled historical shipments may arise for several reasons, such as insufficient data to model early replacements or changes in the mean replacement time of the products over time.

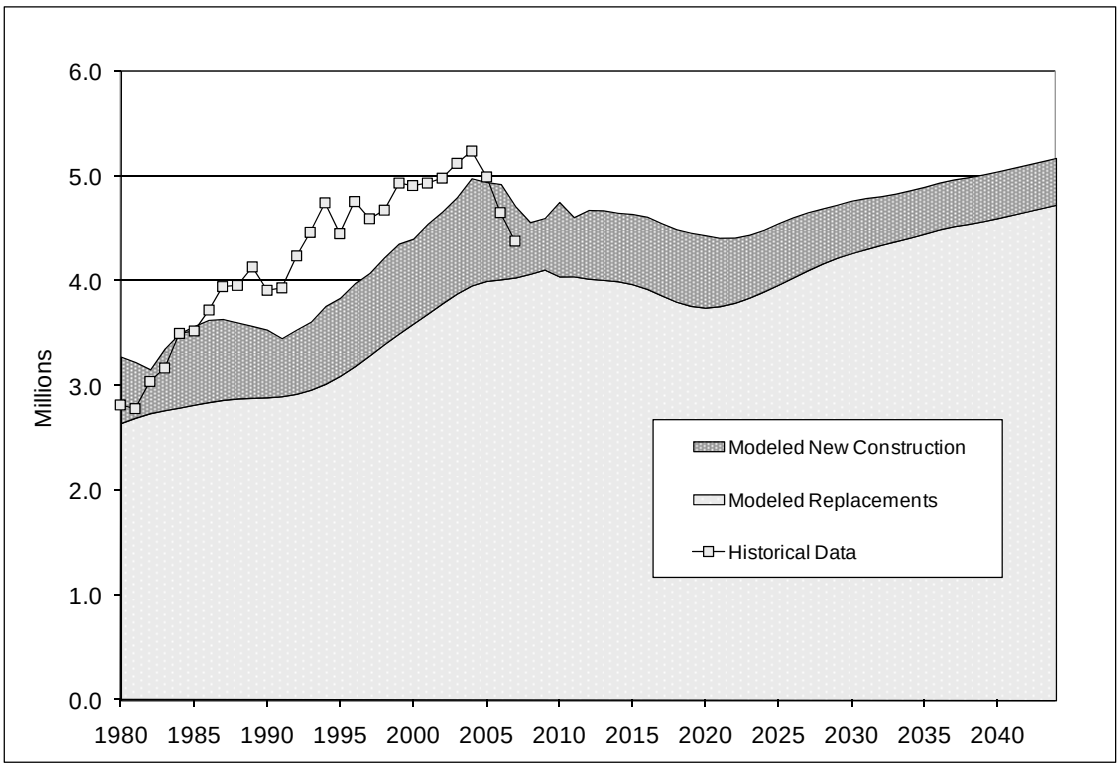

Figure 9.4.1 Gas-Fired Storage Water Heaters: Historical and Modeled Shipments

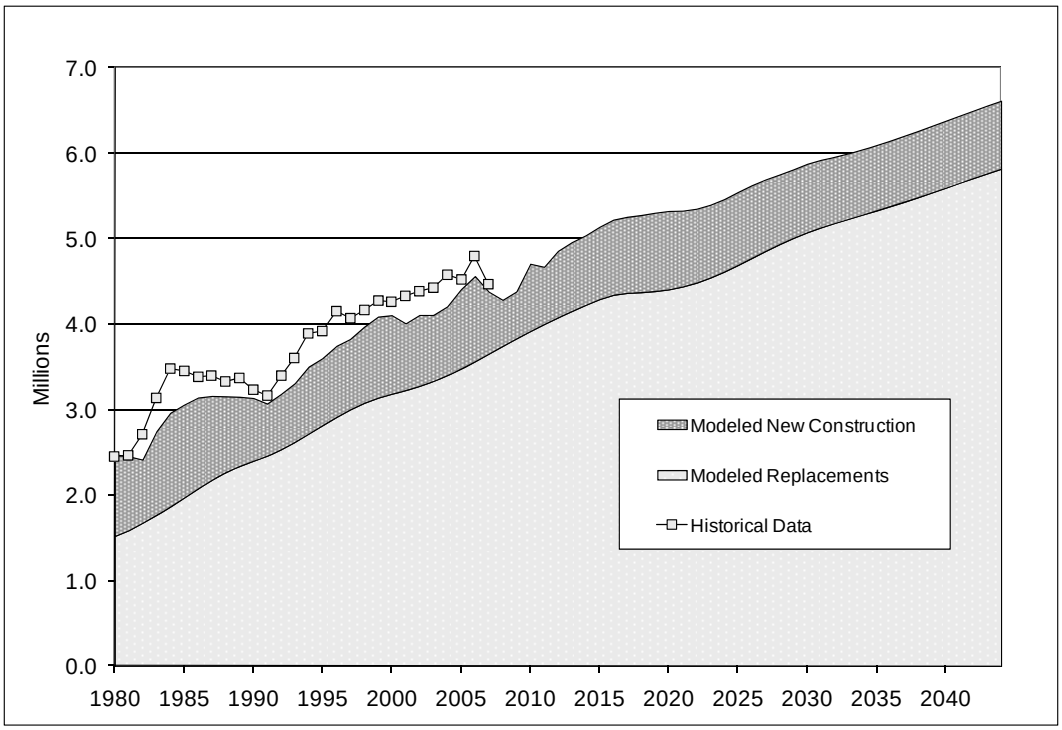

Figure 9.4.2 Electric Storage Water Heaters: Historical and Modeled Shipments

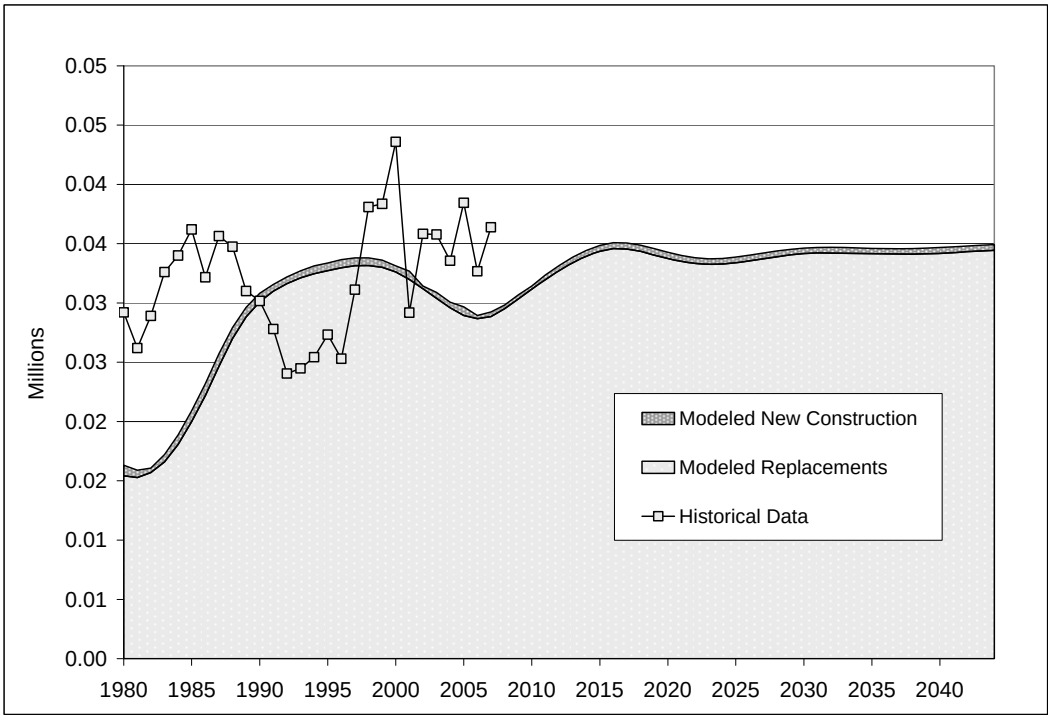

Figure 9.4.3 Oil-Fired Storage Water Heaters: Historical and Modeled Shipments

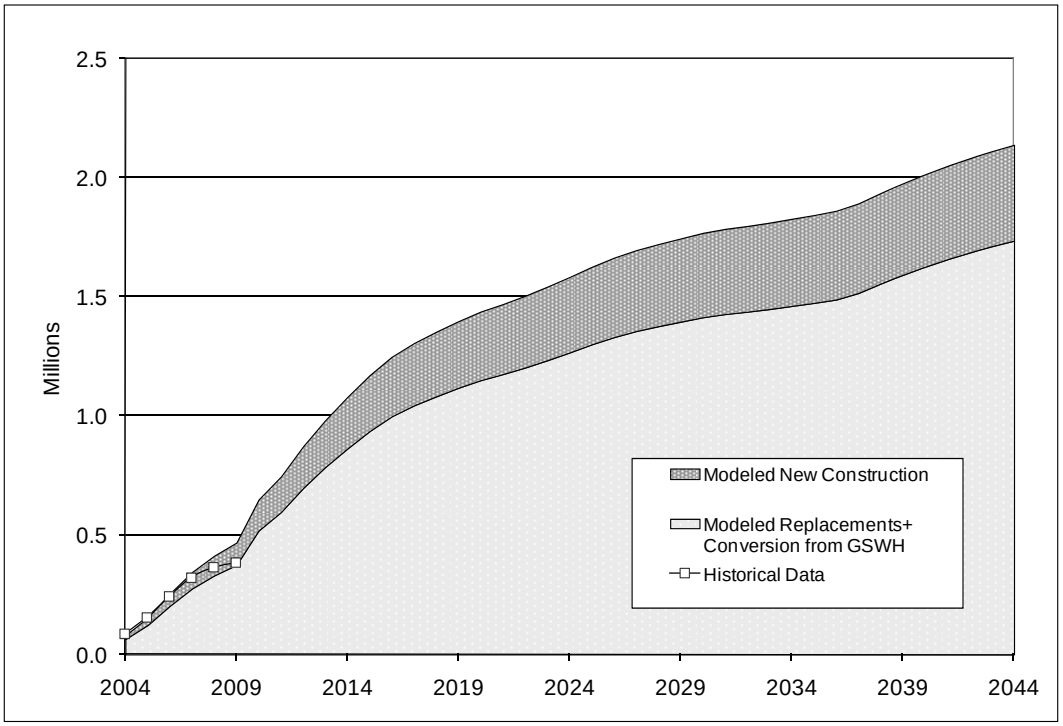

Figure 9.4.4 Gas-Fired Instantaneous Water Heaters: Historical and Modeled Shipments

9.4.2 Direct Heating Equipment

Figures 9.4.5 and 9.4.6 show the historical and modeled shipments for each product class of direct heating equipment.

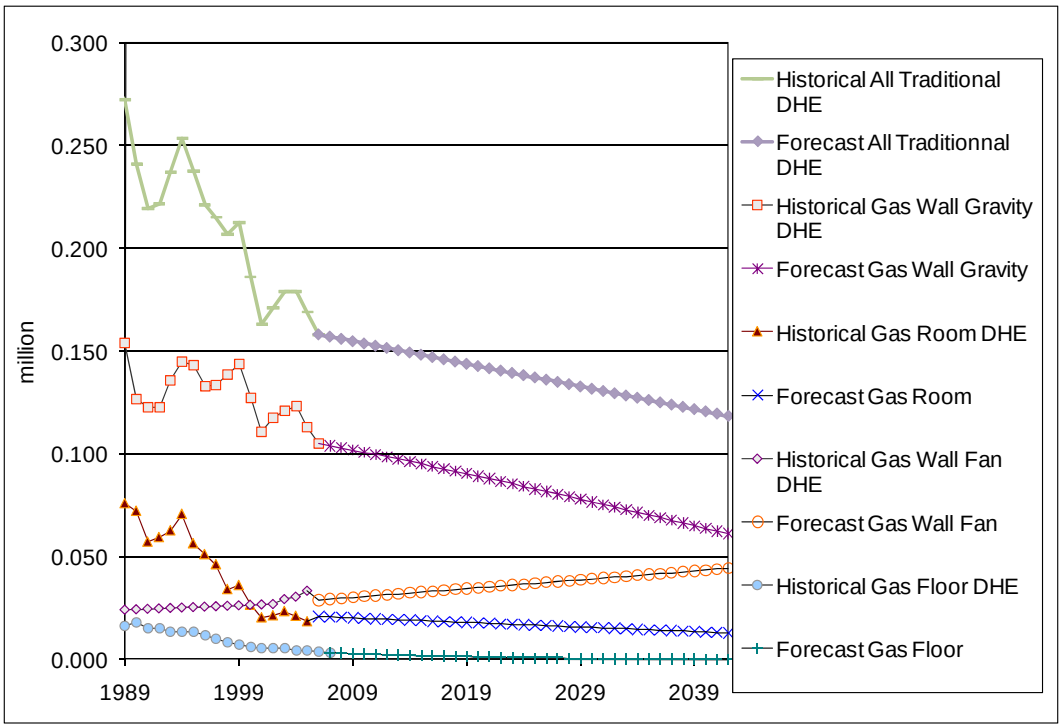

Figure 9.4.5 Direct Heating Equipment (Traditional): Historical and Modeled Shipments by Product Class

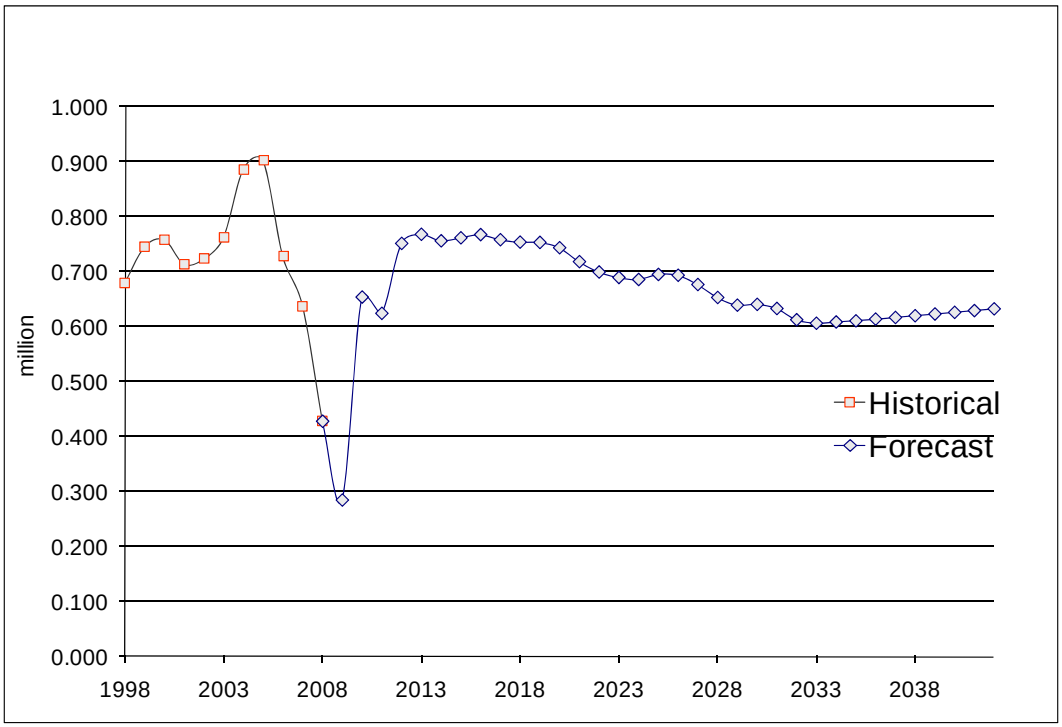

Figure 9.4.6 Gas Hearth Direct Heating Equipment: Historical and Modeled Shipments

9.4.3 Pool Heaters

Figure 9.4.7 presents historical and modeled shipments of gas-fired pool heaters. Shipments are disaggregated into the following market segments: replacements, new housing, and FTOs.

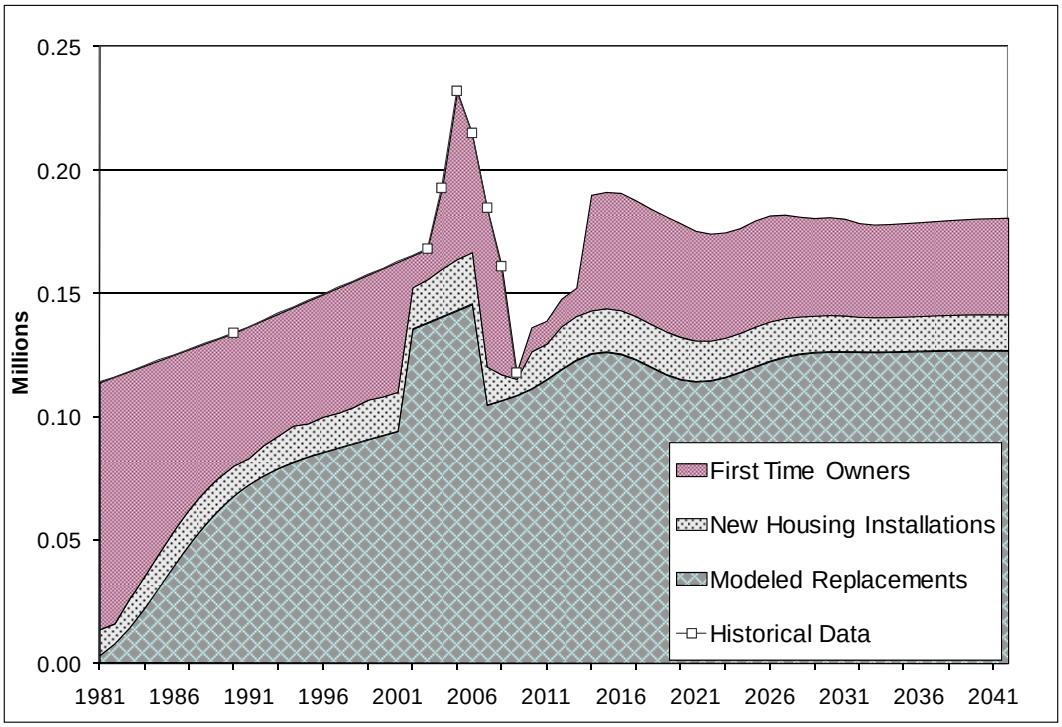

Figure 9.4.7 Gas-Fired Pool Heaters: Historical and Modeled Shipments

9.5 IMPACT OF ENERGY CONSERVATION STANDARDS ON SHIPMENTS

To the extent that revised energy conservation standards result in an increase in the price of a covered product compared to a competing product, some consumers (or home builders in the case of shipments for new construction) may purchase the competing product. DOE's analysis seeks to account for such "product switching."

9.5.1 Water Heaters

Three of the four product classes for water heaters compete to some extent. The competing classes are gas-fired storage water heaters, electric storage water heaters, and gas-fired instantaneous water heaters. It is useful to consider the nature of the competition in the replacement and new construction market segments separately in order to assess the potential impact of energy conservation standards on shipments.

9.5.1.1 Replacement Market

When replacing a gas-fired storage water heater, switching to an electric product involves substantial cost because of the complexity involved in modifying the installation.[9] Ordinarily, 30-amp electric wiring is not available near an existing gas-fired water heater. Providing such a circuit is expensive, and the main electric service panel may be inadequate for accepting the circuit. In addition, because it takes more time for an electric storage water heater to recover heated capacity, a larger electric tank is required to replace a gas unit. Therefore, changing from a gas-fired unit to an electric one entails significant expense. Consumers might be induced to switch from gas to electric only if there was a large increase in the price of a gas-fired water heater compared to an electric one. Because DOE does not envision a set of revised energy conservation standards that would result in such an increase, its analysis did not include switching from a gas-fired to an electric storage water heater in the replacement market.

It is possible that a purchaser will switch from a gas-fired storage water heater to a gas-fired instantaneous water heater. Although the installed price of a gas-fired instantaneous water heater is currently much higher than that of a gas-fired storage water heater, the popularity of gas-fired instantaneous water heaters has increased in recent years, and DOE forecasts substantial growth in their market share. If energy conservation standards significantly increase the price of gas-fired storage water heaters compared to instantaneous water heaters, some additional consumers might be induced to switch to the latter product. DOE is unaware of data for estimating such switching, however, because market competition between gas-fired storage water heaters and gas-fired instantaneous water heaters is a relatively new phenomenon. DOE, however, will consider the potential for impacts from switching when evaluating candidate standard levels.

Switching from an electric storage water heater to a gas-fired water heater also may occur in the replacement market. DOE's life-cycle cost (LCC) analysis indicates that the energy efficiency provided by electric heat pump water heaters produces large average LCC savings. Because this type of product has a higher installed cost than does a typical gas-fired storage water heater and is relatively new to consumers and builders, DOE analyzed the potential for switching from an electric heat pump water heater to a gas-fired water heater. DOE considered all the potential combinations of switching from the max tech electric heat pump water heater standard level (2.35 EF at 50 gallon) to each of the gas-fired storage water heater standard levels. For simplicity DOE assumed that the fuel switching results would be similar for electric heat pump water heater standard level at 2.00 EF (50 gallon).

DOE used data from the EIA's 2005 Residential Energy Consumption Survey (RECS 2005) to estimate the percentage of households expected to purchase an electric water heater in the base case that could switch to a gas-fired water heater. First, all households that use an electric water heater were selected, assuming that those households reasonably represent future consumers of electric water heaters. Then, households that have no gas hookup were removed because they would be very unlikely to switch to gas-fired water heating. Finally, households that had no central gas-fired furnace or boiler were removed, because the cost of venting and gas piping for a gas-fired water heater would be prohibitive. The remaining households—those that

could switch to gas water heating—account for about 13 percent of the total households that have electric water heaters.

To estimate how many of the households that could switch to gas-fired water heaters would do so, DOE considered the difference in installed cost between a gas-fired storage water heater and an electric heat pump water heater in each of the combinations listed above. To do this, DOE performed a Monte Carlo simulation comparing installation costs for each household in the RECS 2005 subsample for electric water heaters. If the total installed cost of the electric heat pump water heater was greater than that of the gas-fired storage water heater, DOE assumed that a switch would occur.

DOE did not quantify the potential for switching to gas water heating in the case of a standard that requires 0.95 EF for electric water heaters, as the installed cost is only moderately higher than the baseline electric water heater (0.90 EF), and DOE judged that this would not be sufficient to prompt consumers to consider switching to gas water heating, especially given the costs involved in such switching

9.5.1.2 New Construction Market

For home builders, the choice of a water heater depends primarily on the availability of natural gas.[9] If gas is available, builders generally will install a gas-fired water heater (and usually a gas furnace). If gas is not available, but the utility says that it will be available soon, the developer will install a temporary central propane tank until natural gas is available. If natural gas will remain unavailable for the foreseeable future, as is the case in parts of the Pacific Northwest and Florida and in most rural areas of the United States, builders usually will install an electric water heater.

Price has little effect on the builder's choice of water heater because generally the water heater is a small part of the total cost for plumbing a new house. The builder pays attention primarily to the total plumbing cost, not individual components. Small changes in the cost of the water heater therefore are unlikely to induce a builder to switch to a different product.

To assess the likelihood that a builder would switch from an electric heat pump water heater to a gas-fired storage water heater in new home construction, DOE first developed a sample of RECS households to serve as a proxy for future new homes that have electric water heating.[a] Then households were selected that potentially could switch from electric to gas-fired water heating because natural gas is available. This group contains 7 percent of all RECS households in the sub-sample that has electric water heating (most new homes that have electric water heating do not have access to natural gas). Similarly to the replacement case, DOE performed a Monte Carlo simulation comparing installation costs for each household in the RECS 2005 subsample for electric water heaters. In total, DOE estimated that less than one percent of new homes with electric water heating would switch.

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[a] For new construction, DOE began with a subset of those RECS households having electric water heaters that were built in the most recent period before the survey.

Gas-fired instantaneous water heaters are a relatively new option for home builders. In new construction, the difference in installation cost between a gas-fired instantaneous unit and a gas-fired storage unit is less than in replacement applications, because the new home could be built with a larger gas pipe, larger vent pipe, and electrical wiring that are sometimes required. DOE's shipments forecast accounts for the fact that in the future some builders likely will find instantaneous water heaters attractive. If energy conservation standards result in a large price differential between storage and instantaneous water heaters, the standards may affect builder choice. However, DOE currently is unaware of data that would enable accurate quantification of such effects.

9.5.1.3 Summary of Estimated Water Heater Fuel Switching

Table 9.5.1 summarizes the percentage of electric water heater shipments in the base case that DOE estimates would be switched to gas-fired storage water heaters for each of the standards combinations.

Table 9.5.1 Estimated Percent of Base Case Electric Water Heater Shipments that Would Switch to Gas-Fired Water Heaters

Technology Combination Resulting from Standards	Percent that Switch *(%)*	
	New Construction	Replacements
HPWH and Gas-fired WH using natural draft (EL 0)	0.4%	7.6%
HPWH and Gas-fired WH using natural draft (EL 1)	0.0%	5.2%
HPWH and Gas-fired WH using natural draft (EL 2)	0.1%	4.8%
HPWH and Gas-fired WH using power vent (EL 3)	0.0%	9.4%
HPWH and Gas-fired WH using power vent (EL 4)	0.0%	9.1%
HPWH and Gas-fired WH using power vent (EL 5)	0.0%	8.6%
HPWH and Gas-fired WH using condensing technology (EL 6)	0.0%	0.1%

Figure 9.5.1 shows the total effect on shipments of electric storage water heaters in the case of a standard level that would require a heat pump design. The figure shows projected shipments without switching and projected shipments in the cases of heat pump water heater switching to gas-fired water heater using natural draft (EL 2), power vent (EL 3), and condensing technology (EL 6).

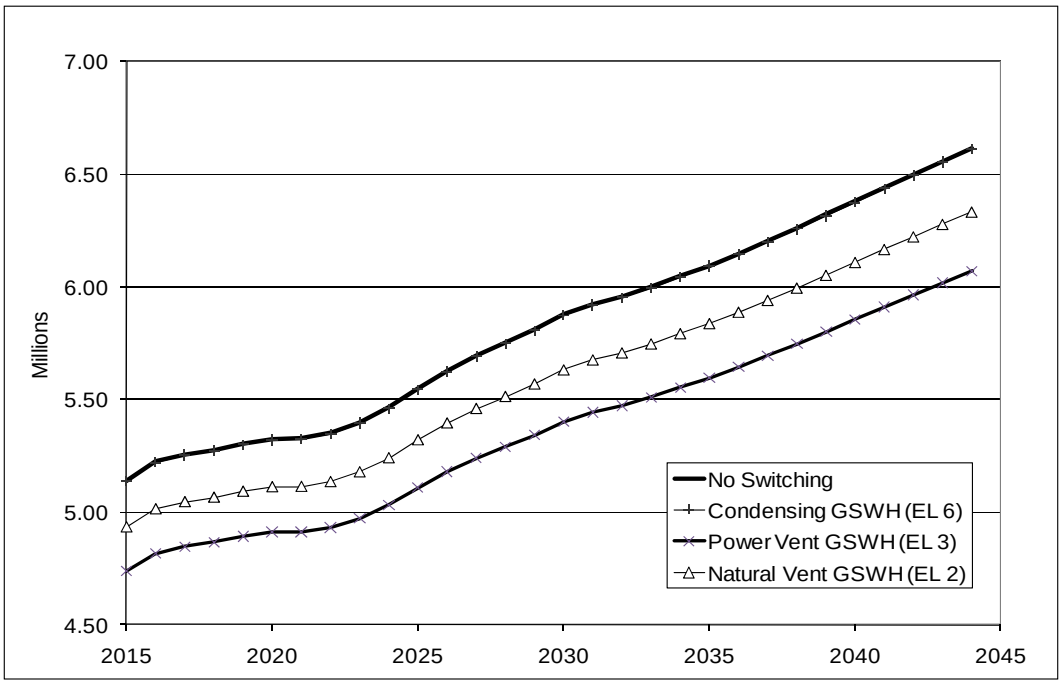

Figure 9.5.1 Shipments of Electric Storage Water Heaters Given a Standard Requiring Heat Pump Design, Accounting for Switching to Gas Water Heaters

9.5.2 Direct Heating Equipment and Pool Heaters

If energy conservation standards result in increased prices for gas-fired DHE, some consumers may purchase electric direct heating equipment or postpone or forego purchase. Similarly, some consumers who have a pool may forego purchasing a gas-fired pool heater if energy conservation standards result in increased prices. In both cases, however, DOE is unaware of any data that could be used to estimate the magnitude (elasticity) of the response to higher purchase price.

9.6 SWITCHING FROM LARGE WATER HEATERS IN THE CASE OF TSL 5 AND TSL 6

As discussed in chapter 10, TSLs 5 and 6 include efficiency levels that require heat pump technology for electric storage water heaters with rated storage volumes at and above 56 gallons, and efficiency levels that require condensing technology for gas-fired storage water heaters with rated storage volumes at and above 56 gallons. These TSLs would present consumers of large-volume water heaters with a total installed cost that could lead some of them to consider alternatives to purchasing a new large-volume water heater. This might occur in either replacement or new construction applications. To estimate the likely incidence of switching away from large-volume units under TSL 5 and TSL 6, DOE considered several alternatives to purchasing a large water heater, as well as constraints that would likely limit their adoption.

First DOE considered factors that would cause some households to choose not to install an alternative to a new large-volume unit. Most important is the need for emergency replacement, which, according to comments on the NOPR could account for as much as 95 percent of water heater replacements.[10] This may preclude consideration of switching, which would usually take more time. In addition, based on shipments data from AHRI,[11] equipment stock information from AEO 2010,[2] and data from RECS 2005[12] on the fraction of households with a gas furnace that also have a gas water heater, DOE determined that at least 15 percent of furnace shipments go to households that are switching from non-condensing to condensing gas furnace and also have a gas water heater.[b] Some of these households may decide to install a condensing gas water heater to avoid complex venting system modifications. Another factor that could cause some households to choose not to install an alternative to a new large-volume unit is if the homeowner assigns a high weight to the operating cost advantages of a heat pump water heater or a gas condensing water heater. DOE judged that the above factors would reduce the fraction of installations that might consider an alternative to purchasing a large-volume water heater by 25 percent.

One alternative applicable to both gas-fired storage water heaters and electric storage water heaters involves installing a small-volume water heater, increasing the setpoint and applying a tempering valve. DOE believes that this strategy would only be viable for a fraction of 66-gallon units. To assess the viability of this approach for each of the sample households with 66-gallon water heaters, DOE calculated whether the first-hour rating of the small-volume water heater with a tempering valve would meet the first-hour rating of the existing 66-gallon water heater without exceeding a 140 degree F setpoint. If so, DOE assumed the household would choose this option. The results of DOE's analysis indicate that switching away from a large-volume water heater using this strategy would occur in 20 percent of large-volume electric storage water heater installations and in 4.4 percent of large-volume gas-fired storage water heater installations.

For gas-fired storage water heaters, DOE considered the approach of switching to a small-volume unit with high input capacity. DOE understands that designs for units below 56 gallon rated volume that have very high rated input (e.g., 75 kBtu/hr) are not common. There are some 50-gallon models with an input of 65 kBtu/hr; these designs usually incorporate a 5-inch internal flue tube (instead of 4-inch), and the tank is usually taller to accommodate the same water storage volume. These units are likely to require venting modifications (upgrade to 4-inch vent). In addition, for many installations the input rate for the existing 66-gallon or larger unit is already 55 kBtu/hr or higher, and a 50-gallon unit with a high-capacity burner may not satisfy the household hot water requirements. DOE accounted for the above constraints, as well as for the higher cost of a 50-gallon unit with a high-capacity burner, to estimate the fraction of installations that would switch to a small-volume unit with high input capacity. DOE did not use this strategy for electric storage water heaters since nearly all volume sizes have similar-sized heating elements. The results of DOE's analysis indicate that switching away from a large-

[b] See Appendix 9-A for details.

volume water heater using this strategy would occur in 6.7 percent of large-volume gas-fired storage water heater installations.

DOE then considered the alternative of installing two small-volume gas or electric storage water heaters. For each sample household with a large-volume water heater that, according to DOE's estimation, would not adopt either of the two strategies described above, DOE first considered space constraints that would limit this approach, depending on the water heater location. For those households judged not to have such constraints, DOE compared the total installed cost of either a heat pump water heater or a gas condensing water heater with the alternative of installing two small-volume units. For the cost of this alternative, DOE used information from a consultant report.[13] Because installing two small-volume units is more complicated and takes longer, DOE assumed that households would choose to install two small-volume units only if their total installed cost was 10 percent or more less than the cost for a heat pump water heater or a gas condensing water heater. The results of DOE's analysis indicate that switching away from a large-volume water heater using this strategy would occur in 16.6 percent of large-volume electric storage water heater installations and in 11.7 percent of large-volume gas-fired storage water heater installations.

The final results of DOE's analysis indicate that switching away from a large-volume water heater would occur in 37 percent of large-volume electric storage water heater installations and in 22 percent of large-volume gas-fired storage water heater installations. Appendix 9-A provides further details on DOE's analysis of switching away from large-volume water heaters under TSL 5 and TSL 6.

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